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WEATHER AND CORN MATURITY IN IOWA

By CHARLES D. REED

[Weather Bureau, Des Moines, Iowa, October 20, 1927]

There is a well-defined tendency for corn in Iowa to become more and more damaged by frost before it reaches maturity. What to do with the soft corn becomes a serious matter when the amount of such corn is greater than can be readily absorbed by feeding to animals. It is the purpose of this study to examine some of the possible weather and other causes of frosted corn.

For the period of 37 years, 1890–1926, inclusive, the long-time trend in yield of corn is upward at the rate of 0.28255 bushel per acre per year, calculated by the least square method. In the same period the corn that escaped frost damage has decreased at the rate of 0.549 per cent per year. These trends are shown by Figure 1. Dividing the maturity trend by the yield trend we get a decrease in maturity of 1.9 per cent for each bushel per acre increase in yield. In the 10 years, 1890–1899, 95 per cent of the corn on the average escaped frost, while in the last 10 years 80 per cent of the crop escaped, and in the last 5 years only 73 per cent. This scarcely leaves a doubt that the farmers of Iowa by breeding for large yields per acre have sacrificed maturity of the crop. Perhaps the yield might have been increased without sacrificing maturity, if maturity had been made a coobjective, but apparently this has not been done.

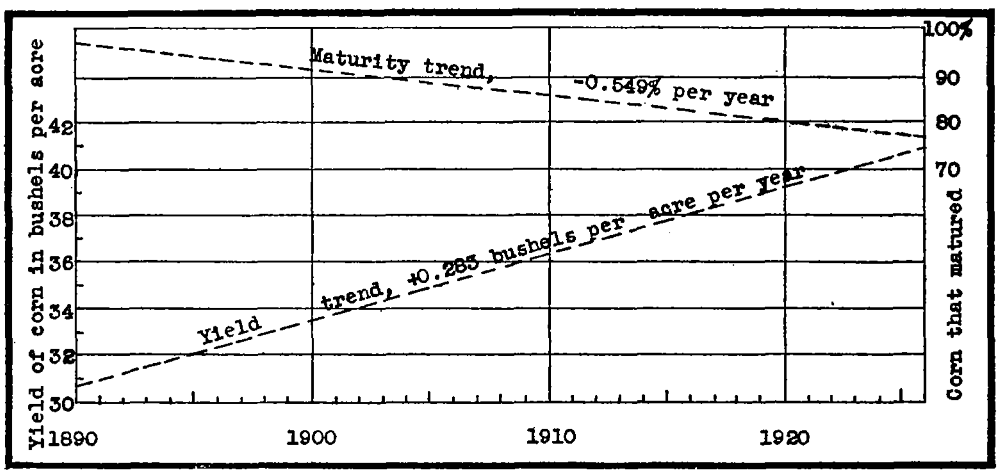

FIG. 1.—Trend of yield per acre and maturity of corn in Iowa

TENDENCY TO LATER AUTUMN FROSTS [1]

Yet a question naturally arises as to whether the first killing frost in autumn has shown a tendency to become earlier. State-wide frost tables were not compiled until 1904 nor can a good distribution of stations be selected prior to 1893. Even the best cooperative observing stations have occasional breaks in their records. Stations in the growing cities and larger towns could not be used because the trend might be vitiated by city influences which are probably more potent in relation to the occurrence of frost than to most other meteorological phenomena.

However, a selection was made of 12 well-distributed stations having nearly complete records from 1893–1926. The stations selected were Rock Rapids, Algona, Alta, Mason City, Iowa Falls, Postville, Logan, Winterset, Clarinda, Iowa City, Oskaloosa, and Bonaparte. The average date of first killing frost or temperature of 32° F., or lower in autumn was computed for the 12 stations for each year. The general dependability of the data is shown by the fact that the average of these 34 yearly averages is October 4, which agrees closely with the average of about 135 records recently used in constructing revised frost maps of the State of Iowa. City stations were not included in the 135. In a few test years for which state-wide averages are available, the 12-station average differs slightly from the State average as might be expected, yet for the purpose of determining the long time trend it is believed that the 12 stations are as useful as the 100 stations, approximately, that have been maintained.

The autumn frost tendency for this 34-year period is to grow later at the very inappreciable rate of 0.0361 day (52 minutes) per year. This for practical purposes is negligible for it amounts to a total of only 1.16 days in the 34 years and would probably disappear if a record of sufficient length were available. But this trend serves the useful purpose of reassurance that the increase in frosted corn is not due to earlier autumn frosts. The average of individual years and the trend are graphically shown by Figure 2. It will be noted that the earliest State average frost in this period was September 20, 1896, 1916, and 1918, and the latest October 25, 1914. A study of rather meager data back to 1873 leads the writer to believe that the earliest general killing frost in

[1] The average of 107 stations was Oct. 4, but the 12-station averages were used for comparison because the average of the 107 stations was not available in 1915.

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Iowa was on September 8–9, 1883. Practically no correlation exists between the average dates of first killing frost in autumn and the percentage of corn that escapes frost, though the data are not here presented.

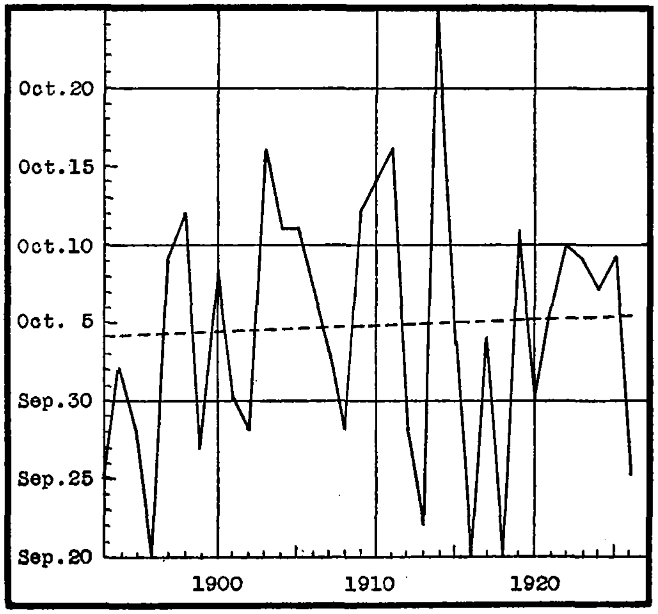

FIG. 2.—Date of occurrence and trend of first killing frost in autumn for the State of Iowa, based on the records of 12 selected stations. Frosts now come about a day later than they did 34 years ago. The trend is shown by the sloping broken line

SEASONAL TEMPERATURE AND RAINFALL INDICATE MATURITY

Low seasonal (June, July, August, and September) mean temperatures are unmistakably associated with low maturity, especially when the season is also wet; while seasonal mean temperatures of 71° or higher produced a maturity of 92 per cent or higher in all of the 11 occurrences. The temperature-maturity curve (fig. 3) indicates that about 80 per cent of the Iowa corn crop of 1927 will escape frost damage. Data on this feature from nearly 1,000 crop reporters will be available about November 10. It will be interesting to see how the two compare. In general the percentage of corn that matures without frost damage decreases roughly at the rate of about 2½ per cent for each additional inch of rain during the season, though the relationship is better expressed by a more complex curvilinear formula, and at best it is not reliable because temperature is the more important factor.

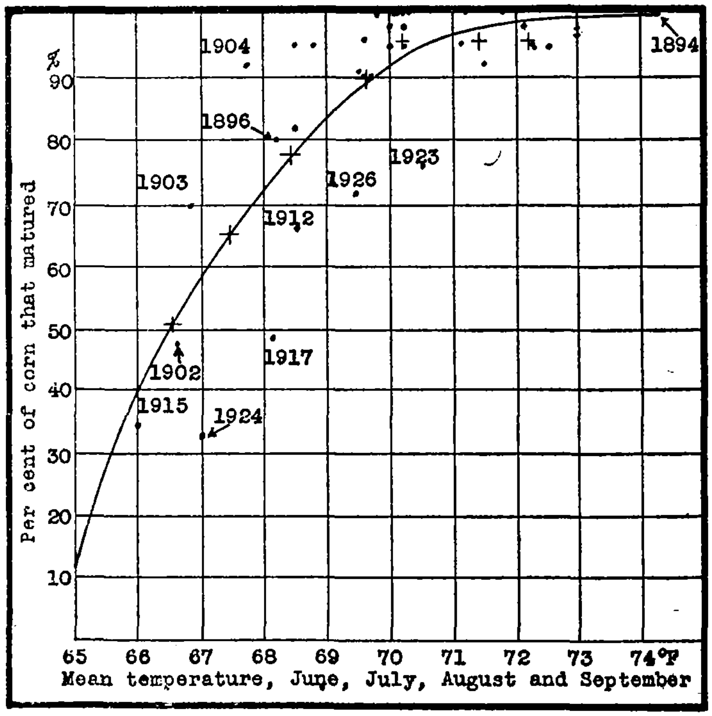

FIG. 3.—Relation between seasonal mean temperature and corn maturity in Iowa. Dots show data for individual years. Crosses show the average temperature between the whole degrees and the corresponding average maturity

SEASONS GROWING SLIGHTLY WARMER

Though maturity is closely related to seasonal mean temperature, the seasonal temperature trend shown by Figure 4 is upward and therefore favorable, yet inappre-

FIG. 4.—Iowa summers have shown a tendency to grow warmer at the inappreciable rate of 0.003° per year or a total change of 0.1° in 38 years. The sloping broken line shows this trend. In another such period this tendency might disappear

ciable, since it amounts to only 0.003° per year or a total of only 0.1° in 38 years and would probably disappear in a longer record. Therefore the increase in frosted corn can not be attributed to a tendency to cooler seasons. The coolest season in 38 years was 1915, with a mean temperature of 66°, and in that year only 35 per cent of the corn escaped frost though the average date of frost for the 12 selected stations was October 4, the same as the 37-year average. Ten other seasons out of 38 were cooler than 1927. Including only the three summer months—June, July, and August—the lowest mean was 66.8° in 1915; and five other seasons since 1890 were cooler than 1927. Including the five months, May to September, the mean of 1927 is 66.6°, and there are 10 colder periods out of 38. The frost damage of 1915 was surpassed only by that of 1924, when only 33 per cent of the crop escaped. The seasonal mean temperature of 1924 was 67°. Being 1° higher than in 1915, it should have resulted in more safe corn, but nine more years of effort to increase yields more than offset the more favorable temperature conditions. The average date of frost as shown by the 12 selected stations in 1924 was October 7,[1] or three days later than in 1915. The seasons 1902 and 1903 were cooler than 1924, but not so much corn was frosted, for the efforts to increase yield had not gone far at that time.

CORN PLANTED LATER

There are some indications that the bulk of the corn planting in Iowa in recent years has been done later than formerly, though the data are insufficient and inconclusive; and furthermore late planting is not always followed by low maturity. Kincer points out the relation between the mean daily temperature of 55° in spring, the average date of occurrence of last killing frost in spring, and the average date of beginning of corn planting.[2] No data being available as to average date of planting the bulk of the corn the writer set about making an annual statistical inquiry, receiving returns from about 100 to nearly 300 well-distributed farmers as to the date of planting their "main fields." Seven years of these data are now available. There is not much relation between planting and frost date in individual years. For example, in 1925 the average date of last killing frost was May 24, the latest in the 35 years of record,[3] and the average date of planting that year was May 10, the earliest of the seven years, while in 1927 the average frost date was April 24 and the planting date was May 21, the latest of the seven years. However, the spring frost date trend shown by Figure 5 is to grow later at the rate of 0.2557 day per year or a total of about nine days in 35 years and if data were available as to date of planting the bulk of the crop, perhaps these might show a similar trend. The average date of last killing frost in spring for the State of Iowa is May 2 and on this date the statewide normal temperature is 55.3° which checks closely with Kincer's results.

The average date of planting "main fields" of corn in the seven years, 1921–1927, is May 14 and the average temperature of the 7 years on that date is 56.8°. The 46-year normal temperature on May 14 is 60.2°. The difference, 3.4°, may be some indication of the lateness of planting in the last seven years as compared with the average. The normal, 56.8°, comes about May 6, so the lateness of the last seven years would seem to be about eight days. As the total lateness of the frost trend is nine days, there seems to be a coincidence if not a relationship here. Like other weather trends, this tendency to late spring frosts will no doubt soon disappear and in any event its effect on corn maturity is not important.

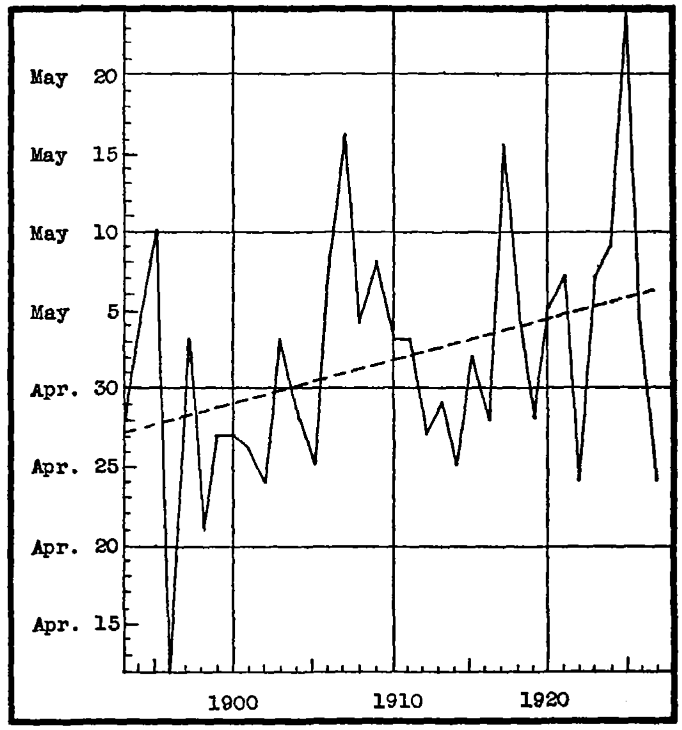

FIG. 5.—Date of occurrence and trend of last killing frost in spring for the State of Iowa, based on the records of 12 selected stations. Frosts now come about nine days later than they did 35 years ago. The trend is shown by the sloping broken line. In a longer record this tendency would probably disappear

While the seven-year period is too short for reliable conclusions, the data seem to indicate that there is a relationship between the mean temperature for 10 days before planting and the date of planting, in which planting is about 0.3 day later for each degree cooler and that each 0.1 inch of rain in the same period delays planting about 0.6 day. The mean temperature of the month of May for 38 years shows a very slight but inappreciable upward tendency, while the April tendency is about equally downward. Late planting sometimes results from rather remote causes. For example, the late planting in 1927 was mainly caused by the unprecedented rains of September, 1926, which saturated the soil to great depths, and by the rains of April, which were the heaviest April rains in 29 years, rather than from May weather conditions, which were not unusually abnormal. The temperature of the 10-day period preceding the average date of planting May 21, 1927, was 56.3°, which is only 0.3° lower than the average of the seven years. The rainfall in the 10-day period prior to planting was 0.2 inch below normal but the subsoil was saturated, it had no place to go, and it made the surface soil too wet for field work.

PHOSPHORUS AND MATURITY

Another possible cause of increasing lateness in maturity that has been mentioned by some authors, is the continued removal of available phosphates from the soil

[1] The average of 107 stations was Oct. 4, but the 12-station averages were used for comparison because the average of the 107 stations was not available in 1915.
[2] MONTHLY WEATHER REVIEW, May, 1919, p. 315.
[3] Sections of Iowa were visited by a killing frost May 31, 1889, but it is impossible to strike a satisfactory State average with the data available in that year.

by cropping without much effort to replace the phosphates by the use of fertilizers. The value of phosphorus in hastening maturity is well known.

CONCLUSIONS

Placed in the order of rank it is believed that the causes of the increase in frosted corn are about as follows: (1) Breeding for increased yield; (2) decrease in available phosphorus in the soil; (3) later planting due to later frost date and other unfavorable weather conditions. Slight but inappreciable tendencies that should have operated in the direction of improved maturity have been: (1) Later autumn frosts; (2) upward trend in seasonal temperature and also in the temperature of the month of May.

All weather tendencies will probably disappear when a sufficient length of record has accumulated.

SOME RESULTS OBTAINED BY TESTING SOLARIMETERS WITH PYRHELIOMETRIC TUBES

By LADISLAUS GORCZYŃSKI

INTRODUCTION

A large number of comparative readings of solarimeters and pyrheliometric tubes have been made, particularly from March to August, 1927, in Ariana, Tunis, and at Montpellier, in the south of France. It seems desirable to present a short discussion of results obtained at these places and also of the important series obtained at the solar observatory of the United States Weather Bureau through the cooperation of Dr. Herbert H. Kimball and Mr. Irving F. Hand. Furthermore, through the results obtained with pyrheliometric tubes with the receiving surface at normal incidence to the solar rays gave a constant reduction factor, the standardization of the solarimeter, employed for measurements of solar and sky radiation on a horizontal surface, has shown that cover glasses of sufficient diameter are necessary to obtain a reduction factor which will be independent of solar altitude. For the establishment of this important relation I am indebted to Dr. H. H. Kimball, who suggested that the use of larger cover glasses would be essential if caustic and other deflections of the solar rays were to be eliminated. This suggestion has been fully confirmed by the extensive series of measurements made at Montpellier.

In the following sections are presented the results obtained from comparative measurements of solarimeters and pyrheliometric tubes, and it is proven that by using cover glasses 50 millimeters in diameter and 1 millimeter thick the solarimeter coefficients are practically independent of the variable altitude of the sun. Results obtained with pyrheliometric tubes are also tabulated and indicate that the probable error of the reduction factor is small. Values of diffuse sky radiation are also tabulated.

THE TESTING OF PYRHELIOMETER TUBES IN CONNECTION WITH SOLARIMETER BOXES

The pyrheliometer tubes are tested in connection with solarimeter boxes, the construction of which was described in my paper published in the September, 1926, REVIEW, 54:381–384. It will be recalled that the solarimeter is a small portable instrument for measuring solar radiation not only as received upon a horizontal surface but also by the addition of a pyrheliometric tube, the intensity of direct solar radiation at normal incidence. (See fig. 1.)

Using an equatorial mounting and a registering millivoltmeter, a pyrheliograph for automatic recording is easily obtained (fig. 2). The old-style register with inked pen and paper for only 24 hours has been replaced with a new recording millivoltmeter using typewriter ribbons and a continuous roll of paper, which provides for several days of record without attention.

Referring to my paper in the REVIEW for June, 1924, 52:299–301, Figures 1 and 2, it will be recalled that the thermopiles are made of thin plates of manganan and constantan of low resistance (about 8 ohms), with the active junctions arranged on a straight line in the center. In the newer type the thermoelements are covered with a special lacquer and form a rectangular surface without intervening spaces. This is important for horizontal exposure, as it avoids the varying influence of oblique solar rays. The pile is hermetically sealed in dry air under a cover of special flint glass. Those used in the pyrheliometric tubes are of similar construction but differ in the mounting. A sphero-cylindrical lens is generally placed in the outer end of the tube, thus obtaining about a fourfold magnification of intensity. The use of this lens is not obligatory, but it is useful in measuring low intensities, particularly when light filters are employed. An ordinary plain protecting glass is sufficient to obtain good deflections, which can be increased by using a more sensitive galvanometer. For our tests made in the south of France, mostly by my assistant, Mr. L. Lemanski, we have used a pyrheliometric tube with a plain glass. For the comparisons, simultaneous measurements were made with an Ångström electrical compensation pyrheliometer recently received and calibrated. The coefficient value (k) as determined by Doctor Bäcklin at the physical institute of the University of Upsala, Sweden, during the summer and autumn of 1926 was 14.9. The agreement is very good between this value, obtained by comparisons with Ångström's Standard No. 78, and the value

$$K = 60/4.19 \;.\; r/b. \; a. = 14.93$$

where "r," the resistance = 0.2101, Ohm/cm, "b," the width of the strips = 0.2057 cm., and "a," the absorption coefficient = 0.98. For final computations, we have adopted, however, a coefficient value

$$k' = k \times 1.034 = 1.54$$

by adding the well-known correction for the border effect.